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Interactive comment

Interactive comment on "Clustering wind profile shapes to estimate airborne wind energy production" *by* Mark Schelbergen et al.

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Discussion paper

1 General comments

This paper is a useful contribution to better understand the wind energy potential of airborne wind energy systems (AWESs). The investigated onshore and offshore wind regimes make it especially interesting for regions close to the shore such as the Netherlands which this papers wind data is based on. Simulated Dutch Offshore Wind Atlas (DOWA) data is normalized, transformed using principal component analysis (PCA) and clustered to generate generalized wind profiles which are then scaled and fed into a quasi-steady AWES model to estimate power curves and annual energy production (AEP). However, this paper would benefit from a more detailed explanation, validation and justification of the described process. Following are some of the general questions and comments that require further explanation.

Language: Please revise the writing of this paper with regards to the usage of active voice to form shorter more concise sentences. Avoid sentences such as: " Finally, it is demonstrated how a set of wind profile shapes and their statistics can be used to estimate the AEP of a pumping AWE system" (page 1, line 9). Section 2 highlights some but not all text passages with passive voice. Remove repetitive sentences, combine sentences where possible. Avoid filler words and obvious wording such as "vertical wind profile". Some line breaks seem unnecessary as both the preceding and following paragraph are related or continue the same topic.

Figures: Many figures are very similar. The paper might benefit from focusing on one location and moving the figures showing the other locations to the appendix. More detailed captions would improve the understanding of your paper, especially for people who are skimming through the text or are reading the paper for the first time. Try to be consistent with the labels within figures as some figures use circles and others use squares.

Wind data: You are using several different data sets in your analysis which occasionally confuses the reader which could be because of the naming convention you chose: MMIJ, MMC and ML. A simpler naming such as “onshore” and “offshore” could help, especially when skimming through the paper.
I am sceptical about combining offshore and onshore wind data into one data set. It is my understanding that you want to simplify the energy estimation of AWES by creating a general purpose set of wind profile clusters. This could lead to results that are so generalized that their application is not valid in either situation. This averaging effect probably aggravates due to the small number of clusters and the temporal resolution of the data set. Comparing the mean normalized wind speed profiles in Fig. 2 and 10 (as well as Fig. 8 and 11) shows that these profiles are in deed fairly different especially at altitudes up to 300m which is well within the operating range shown in Fig. 18. This difference is further supported by the map in Fig. 15. Please show a validation of your approach (e.g. compare power outputs or wind profile shapes reconstructed against actual simulation) or explain in the text how you validated it.
The usage of data sets in your analysis is as follows:

- Section 3: Normalization, transformation and clustering process with **2D offshore** wind profiles
- Section 4: Compare normalized clustered **2D offshore, onshore, lidar** (7 lines of text) and entire domain
- Section 5: Calculate power curve for **1D scaled onshore** wind profiles
- Section 5: Compare AEP for **1D onshore** and entire domain

This leads to the repetition of similar plots, e.g. Fig.8, 11, 13, 14 which take up a lot of space and hardly additional information content. Therefore, my recommendation is to focus on either the onshore or offshore location, and compare final results such as

power curve and AEP with all data sets. You can choose to move the other figures to the appendix or remove them entirely. Similarly, I recommend removing the lidar section from this paper, because you do not use it in any analysis other than "... cluster profile shapes for both datasets are very similar." A deeper analysis of the differences and commonalities between the data sets would justify keeping all these figures if you choose to keep them.
While you go into great detail explaining the process of normalizing, applying PCA and clustering your wind data, very little detail is given on the denormalization of the wind profiles so they can be used for power estimation. Did you use the cluster centroids i.e. the mean of all the profiles which is not an actual profile that occurs in your data set? Similarly one can argue that the profiles derived from the $mean \pm PC * std$ shown in Fig. 2 and 10 are not actual profiles in the data set. Which range and step size did you use to denormalize the wind speed profiles? Is it possible to determine the wind speed range of each cluster or is this information lost due to normalization? If so it would be interesting to see this range in power curve plot. Validating your approach against actual simulated profiles by comparing energy or power curves would add to the credibility of this paper. This could include a comparison against non-normalized, clustered wind profiles or not PCA transformed profiles or standard log profiles with assumed Weibull distribution etc... Please justify why you go through all this process for 2D wind profiles if you just use the wind speed as an input into your AWES model.

PCA: Which PC and std do you use to derive the profiles column 3 and for of Fig. 2 and 10? Maybe a better representation would be to plot the mean, $mean \pm PC * std$ in one plot with a shaded area in between to highlight the range of possible speeds / velocities? It is my understanding that the justification for using PCA is that it accelerates the clustering process. Is clustering the bottle neck of your analysis or is it the optimization? How does the end result vary comparing transformed and not transformed profiles?

Clustering: Please justfy in the text why you only use the cluster centroids for your analysis and how which uncertainties / inaccuracy this causes? How much does the profile shape within one cluster vary and is this variation reduces by normalizing the data? Clustering labels are not in order. How did you sort them or determine analogies between clusters of different data sets (see table 2)? Comparing clusters like this gives the impression that they have the same profile shape. Cluster centroids are the arithmetic mean of all the data points within this cluster. Therefore, adding or removing a data point changes the outcome of the entire process. How can you compare these clusters in table 2? If only 8 clusters are enough, then why not use existing stability classification (like table 1 in https://www.adv-sci-res.net/6/155/2011/asr-6-155-2011.pdf or https://www.wind-energ-sci.net/4/563/2019/wes-4-563-2019.pdf) based on Obukhov length or Richardson number which are widely accepted and a common meteorological classification?

2 Specific comments including technical corrections

Title: I recommend a more specific title including information such as: ground-gen / pumping mode, mesoscale wind data, but understand that it is personal preference.

2.1 Abstract

page 1

line 1: Why not use AWES abbreviating for Airborne Wind Energy System as commonly used in the community and literature

line 6: Introduce abbreviation DOWA here.

line 10: Mention the derivation of power curves.

line 10: Mention the location where you estimate AEP or add AEP analysis for all sites since it sounds like multiple AEP estimates are compared.

line 11: Define or rewrite the sentence so that it is clear that you compare the amount of clusters necessary to estimate AEP and use concrete results rather than “within a few percent”.

2.2 Introduction

page 1

line 13: AWE already defined in Abstract in line 1.

line 14: Many different concepts exist with varying (anticipated) operating altitudes. Either remove subordinate clause “typically in a range up to 500 m” or explain / reference what this assumption is based on.

line 14: Add reference for stronger and more persistent winds.

line 18: This is not the definition of surface layer. I would stay away from concrete number as the height of the surface layer varies a lot depending on atmospheric condition. Remove or replace with: in the order of tens of meters depending on atmospheric stability (http://glossary.ametsoc.org/wiki/Surface_boundary_layer)

page 2

line 1: Low-level jets are a known phenomena and have been discovered a while ago. Rewrite: “Recent studies have identified numerous low-level jets”

line 4: Remove: “more”

line 9: What kind of “performance calculation”?

line 9: Add reference to COSMO-DE

line 10 & 11: Add: “shape” after wind profile

line 14: Add reference to MERRA-2

line 14 & 16: Malz et. al b) referenced before a).

line 15: Sentence on the reduction of computational cost and choice of initialization seem unnecessary for this paper.

line 20: Add reference and expansion of WRF

line 26: Remove “such a historical dataset”. Does not contribute to the understanding or quality of this paper. What makes this data set so special?

line 34: Add reference to DOWA, ERA5 and expansion of LiDAR (also, check WES house standards on capitalization of abbreviations: https://www.wind-energy-science.net/for_authors/manuscript_preparation.html. One feedback I got was: “WRF is a defined model name (the same applies to the ARW), but lidar is a general term and is therefore not capitalized according to our house standards.”

page 3

line 1: Is the DOWA data set comprised of met mast data? I thought it is derived from reanalysis models which had various measurements assimilated.

line 2: Sentence is a little confusing as it suggests that met mast data is somehow involved. Maybe chose a different naming convention e.g. onshore, offshore.

line 2: “The procedure” is confusing as the previous sentence describes comparing DOWA and LiDAR and not generating a set of representative wind speed profiles from clusters

line 5: More accurate than log profiles or uniform wind? Is it actually more accurate and did you validate the improvement?

line 7: Active voice

2.3 Wind data sets

page 3

line 10: Combine first 2 sentences.

line 16: Repetitive sentence: “Both long-term ...”

line 17: In what way “sparser” lidar? spatial, temporal?

line 21: Repetitive sentence: “... coast in the North Sea”. Also shorten the sentence e.g. “The selected offshore location, met mast IJmuiden, is located 85 km off the Dutch coast.”

line 21: Write out the wind direction as it doesn’t safe lots of space but adds clarity

line 21: Why not use the Cabauw or IJmuiden met masts for validation as well? I thought that was one of the reasons why you chose this location.

2.3.1 ERA5

page 3

line 26: Define and add reference to ERA5 and ECMWF.

line 27: I don’t think the year in brackets as well as the information that more data from years back will be available soon is necessary.

line 31: Replace outputs with a different verb: produces, uses, calculates and rewrite sentence to be more concise

page 4

figure 1: More explanation in caption

figure 1: How and why did you choose the sample location? Are these representative locations?

figure 1: Is it important that you use met mast locations as you don't you met mast data at all.

line 1: Remove sentence: The long-term wind climate is not important for this study as no long-term predictions were made.

line 2: You use ERA5 to determine atmospheric stability. Does DOWA not provide the necessary data?

line 2: Stability is only used for cluster statistics in Fig. 9 and similar. Please expand this analysis and the relationship between clusters and stability.

line 3: DOWA defined on page 2

2.3.2 Dutch offshore wind atlas

page 4

title : Capitalization different from previous DOWA

line 6: How downscaled? Is it not more the extraction of specific values from a data set?

line 6: Add reference to model and / or move link to footnotes

line 10: Add reference

line 11: Remove 2nd "than" and "alone"

line 12: Define or paraphrase "ASCAT" and "mode-s ehs". Add reference

line 13: Sentence about website unnecessary

line 14: Remove "additionally" and conjugate "show" or add et. al

line 15: LLJs are not anomalous

2.3.3 lidar observations

page 5

title : Check capitalization and abbreviation rules for lidar

line 1: Rewrite. I don't know what you want to say with this sentence.

line 4: ECN?

line 5: Add link as reference and / or footnotes

line 6: Where is difference between "clock hour" and hourly?

line 7: Active voice

line 8: Only time you use "data set" instead of "dataset"

2.4 Clustering procedure

page 5

line 12: Mention that you do the same for MMC

line 13: How normalized? Add PCA abbreviation

line 14: rewrite "for choosing", active voice e.g. the number of clusters is chosen based on the clustering performance...

2.4.1 Preprocessing of the wind data

page 5

line 16: Shorten sentence, mention use of all time steps, entirety sounds like more than it is.

line 20: Is that 90th percentile of each time step or of all data points of this altitude or of all data points at 100 m?

line 20: Line break not necessary

line 21: Why did you choose this normalization and why normalize in general if you expect that it will not lead to good results for low winds?

line 21: Active voice. Do you only expect eccentric profiles or did you actually observe them?

line 24: How do you implement them if they are omitted?

2.4.2 Principal component analysis of the wind profile shape dataset

page 5

line 27: Defined above

page 6

line 4: “for every wind direction” = omnidirectional

line 4: The difference to ...

line 5:“logarithmic profile representation of the wind environment” = logarithmic wind profile. Remove one “logarithmic profile”. Introduce z_0 here. Why is $z_0 = 0.0002$?

line 6: “vertical” is understood, wind speed is always magnitude

line 6: Add variable name $u(z)$ and reference to equation

line 8: Add reference or explanation to Obukhov length

line 13: Explain relationship of L and atmospheric stability. Does this sentence mean that the average of multiple years of wind data fits an unstable log profile? Are you fitting wind speed or just parallel component?

line 13: Add reference to “Theory”. Add “mean wind profile...”, remove “in the” & “direction”.

line 13: Add “(top-view in the bottom left panel)”

line 14: Remove “of the wind profile shape”

line 22 & 23: Remove text in parentheses

line 24: Add reference

line 28: Active voice

line 31: Isn’t this a general feature of PC? Remove “Note that”?

page 7

figure 2: What do the number 1-4 in bottom boxes mean? Add normalized to vertical wind profile. Does second column show the mean or is it the orientation of PC axis with height? What does it mean to multiply PC with std? Which std do you multiply with? It might make sense to show the std of each PC in a table. Plots in column 2 are not on the same x-axis. Please explain how PC1 and 2 rotate over altitude.

2.4.3 Number of clusters

page 7

line 6: Either active voice or general statement in which case you should use “a” instead of “the”

line 8: Remove parenthesis. Replace “all” with “each”

line 10: Add reference

page 8

figure 3: Explain legend abbreviations and subset in caption. What is the MMIJ subset?

figure 4: why * on x- & y-axis label? Are the markers the orange circles? Do the numbers 1-4 correspond to the clusters shown in Fig. 2? If so mention this in the caption.

figure 4: Maybe replace “wind profile shape” with wind velocity profile.

line 1: What is “itk” ? Number of clusters is usually the k in k-means clustering

line 5: Delete if not shown. If you keep it in explain “over-fitting” in this context. Probably not happening because of (relatively long) temporal averaging.

line 7: How is the silhouette score calculated? Adding silhouette score and WCSS equation would make it easier to understand. Is a score of 1, 0 or -1 better?

line 9: Remove repeated subject “mean silhouette score”. How do you interpret the decreasing trend? Explain if you mention it, the fact that it is decreasing is obvious.

page 9

figure 5: Which data set do these results belong to: MMIJ, MMC, ML? Are these results the same for all data sets? Expand on the captions.

figure 5 a): y-axis label: Isn’t it the “sum of squared distances” ?

figure 5 a): Add a vertical line at $k = 8$ to highlight your choice.

figure 5 b): Explain non-linear grid lines in caption. Why no vertical grid lines? “...error over height for logarithmic profiles...(...and four different stability...)”, “...three exemplary clusters”. How is the error defined?

line 1: So it would be best to use only 2 clusters to represent the many different wind conditions even though the sum of square distance is way higher and 4

log-fits out perform it? What defines a good silhouette score? Wouldn't it be a fair comparison to also vary the number of log-fits over the x-axis? Why 4 log-fits?

line 2: Why do you show the different approaches to get best k and then use AEP without showing it here?

line 5: Shorten to"filtered wind profile data". Parentheses are repeating what has been said before, remove.

line 5: Remove: "Next, it is..."

line 8: Equation would make it easier to understand.

line 11: More combined than individually, otherwise 2 lines.

line 16: How did you choose these L values? What are the assumed ranges of L associated with certain atmospheric stability?

page 10

figure 6: Why vertical grid line in center of plot? Showing the x-axis as percentage of total data would be better. Briefly explain what positive and negative values mean?

line 5: Is this weighting intended? Why not linear interpolation in z?

line 6: It seems like this is not the only reason. Resolution is high up to 200 m.

line 9: I assume that a low number of clusters is enough to capture variations within the hourly data set which is why I would recommend mentioning that this choice is specific for your temporal resolution.

line 14: Move the last sentence up to the section where you first introduce clusters.

2.5 Wind resource representation based on clusters

2.5.1 Interpretation of prevailing wind profile shapes at MMIJ

page 11

line 10: Are these profiles the centroids of the clusters you calculated before?

line 13: Are these the Obukhov lengths? Which ranges do you associate with each stability condition?

line 12: Replace "...moving between..."

line 13: What are the number in parentheses? Add variable.

line 13: Move line break as veering clearly refers to the previous paragraph.

line 21: Fig 7 is mentioned after Fig 8. Active voice

line 22: Also active voice: "Examining the five PC coordinates in table 1 ...."

line 26: How can that be deduced? Define filter e.g. "low-speed filtered..." as readers might have forgotten or skipped the previous sections.

line 28: Define "calm wind"

line 29: These 2 sentences are more general and introduce the data set. Move up before previous sentences.

page 12

equation 2: Why are you using different Δz for u. v, θ within this equation? Are u. v, θ on different altitudes?

line 6: Why not rewrite Eq. 2 to include absolute temperature instead? Explain how it is used. I guess instead of virtual potential temperature.

line 6: Isn't humidity high close to the shore / offshore and would the effect not be considerable?

line 8: Add "Positive Ri_B values"

table 1: Do these values relate to Figure 2?

page 13

table 2:The cluster centroid shape will change based on the underlying data, i.e. filtered. It seems that you assume that clusters between data sets are same, e.g. cluster 1 is same through out all data sets. Did you sort or determine similarity between cluster centroids of different data sets? How similar are PC transformed and normalized wind data? Can you quantify how similar / different they are?

figure 7: Nice visualization. Why * on x and y label?

page 14

figure 8: Is this the filtered or unfiltered data set? Do all x-axis use the same range, because different label? Explain more in caption, i.e. why $\hat{v}$ over variable, where is the origin of the hodograph / increasing z direction? Better spread out all the graphs so that they appear after mentioned in text. Do you need all these graphs here? Maybe move some to the appendix.

page 15

figure 9: Nice way of comparing the data set. Might be a bit overwhelming at first though. Is this the entire data set or filtered? Where are these Ri bins coming from? Add reference. What do you mean by "Bins have the same overall frequency" ? Wouldn't that mean that all the bars have same height? Do you mean bin width? Use the same comprehensible bin width for all subfigures (especially wind speed and Ri seem arbitrarily chosen) in

figures 9 and 12. Maybe add an “offshore” and “onshore” to data set labels for clarity. A better and easier understandable metric would be atmospheric stability (i.e stable, unstable) instead of using Ri number.

page 16

line 1: Change figure order or reference which figure you mean after 3 pages of figures. “... over the 10 year timeframe”.

line 2: Why is this a prerequisite? You have temporal variations on all time scales. But I guess this way you make sure that your data is not based on outliers.

line 3: Remove sentence and line break. Maybe change order. Why first talk about 9 a) and then all the other figures separately ?

line 5: Rewrite: “... not so frequently strong”. According to figure 9, cluster 1 has an almost even occurrence through all wind speed ranges.

line 5: “are more frequent”.

line 7: Add reference to figure which shows cluster shape.

line 9: “well mixed”. How about shear?

line 26: Remove line break as both paragraphs are about cluster 6,7.

2.5.2 Comparison with an onshore location

page 17

line 5: Vertical is understood. Better write: “The mean normalized wind speed profile...”.

line 8: Same as line 5

line 11: Removing “of the two locations ... ” makes the sentence easier to understand.

line 19: Add the variable to values in parentheses

line 20: So is there no cluster that corresponds to stable stratification without LLJ? If so wouldn’t that be unusual?

line 22: “however” and “just” seem like filler words. You could shorten the sentence

line 24: Active voice.

line 26: Sentence hard to read. Shorten i.e. “This affect is caused by the lower heat capacity of the land surface which promotes a more immediate heat transfer to or from the atmosphere.”

line 30: What is the point of comparing diurnal to seasonal cycles? They are caused by entirely different effects and play out over vastly different timescales.

line 32: What does overall bin frequency mean and why does it have to be equal? It sounds like you are varying your classification to get a certain result rather than try to characterize actualphysical effects.

page 18

figure 10,11,12: More explanation for readers who just skim through the text or just look at figures, i.e. onshore, normalised wind speed, numbers and explain PC*std. Consider moving some figures to the appendix.

2.5.3 Validation with LiDAR observations

page 21

line 1: This paragraph seems rather unnecessary. Very short, no mayor inside, only that results are similar.

line 2: replace “investigate” with “show”..

2.5.4 Spatial distribution of wind profile shapes

page 21

line 10: How did you chose these sample locations in Fig.1? Are 45 grid points the entire domain? Does your selection affect / bias the results? Line break not needed.

line 12: Explain cluster mapping. Why only 8 clusters again? reference previous chapter.

line 13: How can you apply the same mapping to a new data set?

line 16: Remove “be” and shorten / rewrite sentence.

line 18: Remove sentence “Since cluster 1...”

page 22

table 3: Is this a necessary table? offshore / onshore is not a sufficient classification of wind. How did you match clusters from different data sets? Are they the exact same clusters and if not how similar are they?

page 23

figure 13: Is this a necessary figure? Dashed lines missing in legend. Is this based on hourly average lidar data? Do these numbers in circles have any meaning?

page 24

figure 14: Rewrite: many “the” in caption. Maybe a bit more explanation, i.e. which locations are represented.

page 25

figure 15: Add details to captions. Add ML abbreviation. Add reference to fig. 14 for info on clusters. How did you ″map” to a new data set? Meaning of numbers? Use consistent frequency ranges for comparison or justify why you did not.

figure 15: This clear division between on- and off-shore profiles would justify separating the analysis. Wouldn’t this lead to better more detailed results and insights? Please validate and quantify how much information you lose by clustering everything this way rather than off- and onshore individually.

2.6 Fast AWE production estimation based on historical wind data

page 26

title : What is “fast” about this analysis?

line 1: Rather “estimating” than “calculating”

line 2: You went through all the process of explaining the clustering process using MMIJ data set than introduce MMC, lidar and ML to now only use MMC? Why not focus on MMC entirely or apply your power estimation to all data sets?

2.6.1 Determining power curves for AWE systems operated in pumping mode

page 26

line 10: “... differs between ...”. Add reference to flexible-kite sentence.

line 15: Rewrite sentence: “...is ended ... is depowered... is steered ....”. Remove: “the” in front of zenith. Add: “... to the starting position of the traction phase”

line 17: Check capitalization rules for abbreviations.

line 18: Rewrite sentence: “... moves the kite along an idealised flight path conform a series...” ?

line 19: Doesn’t the limitation to lightweight membrane kites mean that the approach is only applicable to soft kites and not “any kind of pumping AWE system” (line 12)?

line 24: I agree that it is justified to use only magnitude wind speed profiles, but why go through all the process of clustering 2D profiles in the first place?

line 26: Explain in more detail how do you derive the power curve and how you scale the normalized profiles.

line 28: Active voice. Mention that aero coefficients are assumed to be constant.

line 31: What means “sufficiently high”? How is the tether reeling speed during reel-in and -out? Is it a constraint or output of the optimization?

line 31: Rewrite to include tether force constraint and that it corresponds to setting a fixed max tether diameter.

page 27

table 4: More descriptive caption.

line 1: What are your control variables? Table 5 contains constraints that you are keeping constant I assume. Maybe write out the optimization formulation?

line 2 & 3: What is the message of these sentences? Optimizations basically always have active constraints. Why do you have to lower the tether force?

What if an increase in elevation angle leads to an increase in wind speed and therefore force?

line 3: Define effective pumping length.

line 8: Rewrite so that you describe where cut-in and cut-out comes from in this sentence or same paragraph.

page 28

table 5: What are these constraints based on? Is actual tether length $l_{min} + l_{pumping}$? Seems like a list of constraints. What are all the constraints? Are these realistic values (add reference)?

line 3: How do you define “steady flight states”? What are the states? Active voice.

line 4: What about reducing lift / flight speed to achieve one figure-of-eight? To which ground station reeling speeds do your constraints correspond? Explain why you chose this constraint.

line 6: Explain the developed module and assumptions etc.

line 9: This sentence explains cut-out limit again, same as line 4.

line 11: Rewrite sentence. “The corresponding cut-in and cut-out wind profiles are shown in figure 17” or so. How did you scale the normalized wind speeds?

line 12: Is the critical height of 80 m related to the minimal tether length, size of device or other parameters?

line 19 & figure 24: If wind speeds at 80 and 300m are a sensible choice why do you use v_{100} ?

line 25: add “... power curves...”

line 26: Check comma placement

page 29

figure 17: You sometimes use left and right and other times a and b for sub-figures, choose one. More descriptive caption. How did you scale the profiles?

figure 18: Change to “Height” instead of “z” as you always used height before. Add black dashed lines in legend. Why disconnected lines at end of traction phase? Why did you choose this strange v_{100} values? Why not v_{80} instead? Remove: “traction” and “constant” from captions.

line 1: It would be interesting to see reeling speeds, tether force and other variables during one production cycle.

line 4: Why is a profile with LLJ the last to reach cut-out speeds? I would have expected it to cut-out earlier. Is it because of the height of the LLJ?

2.6.2 Estimating the Annual Energy Production

page 30

figure 19: Seems like the profile shape has almost no impact especially at lower wind speeds where the power ramps up. Remove: “... that are ...”. What is the actually wind speed range of each non-normalized cluster? How come the power curve does not plateau and bend down before cut-out?

line 4: f for frequency of occurrence rather than p for probability as I assume it is based on the data you used and not a model like Weibull. It would be great if you could show the distribution of wind speed frequency. Remove apostrophe: “... is the systems power curve....”

line 7: No line break needed.

line 8: How constructed? Equation?

page 31

figure 20: How about MMMIJ? How does the AEP and power curve compare to log profiles with Weibull distribution?

line 3: Did you use 50 calculations to get the power curves of 8 clusters, i.e. more than 6 wind speeds per cluster?

2.7 Conclusions

page 31

line 7: What is “fast” about the calculation? Do you mean simplified? Rewrite e.g.: “... used to estimate AEP for a simplified pumping-mode AWES ...”

line 11: Shorten to: “...simple logarithmic profiles...”. Would be good to compare power curve and AEP against these log profiles.

line 12: For hourly average profiles. What could be the impact of higher resolution data?

line 13 & 14: Shorten: Both locations show similar results.

line 14: Which samples do you refer to, all, MMC, MMIJ?

line 21: I am not convinced by this conclusion. Why does profile shape similarity proof that clustering is able to differentiate between atmospheric conditions? Also which conditions? If only stable and unstable two clusters might be enough.

line 21: Is your process able to determine atmospheric stability (with a certain confidence) solely based on wind profile shape? If so that would be a great addition to your analysis.

page 32

line 3: Which wind resource presentation?

line 4: How did you get a distribution from profiles? Would be interesting to see which cluster/ time of year or day contributes how much to AEP.

line 7: How do 25 optimizations relate to 4 clusters or wind speeds?

line 11: How high is the error in comparison to single location clustering?

line 12: Add line break in front of “In the future...”

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